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Comparing the effect of auditory-only and auditory–visual modes in two groups of Persian children using cochlear implants: A randomized clinical trial

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ABSTRACT

Objective: Since the introduction of cochlear implantation, researchers have considered children's communication and educational success before and after implantation. Therefore, the present study aimed to compare auditory, speech, and language development scores following one-sided cochlear implantation between two groups of prelingual deaf children educated through either auditory-only (unisensory) or auditory–visual (bisensory) modes.
Design: A randomized controlled trial with a single-factor experimental design was used.
Methods: The study was conducted in the Instruction and Rehabilitation Private Centre of Hearing Impaired Children and their Family, called Soroosh in Shiraz, Iran. We assessed 30 Persian deaf children for eligibility and 22 children qualified to enter the study. They were aged between 27 and 66 months old and had been implanted between the ages of 15 and 63 months. The sample of 22 children was randomly assigned to two groups: auditory-only mode and auditory–visual mode; 11 participants in each group were analyzed. In both groups, the development of auditory perception, receptive language, expressive language, speech, and speech intelligibility was assessed pre- and post-intervention by means of instruments which were validated and standardized in the Persian population.
Results: No significant differences were found between the two groups. The children with cochlear implants who had been instructed using either the auditory-only or auditory–visual modes acquired auditory, receptive language, expressive language, and speech skills at the same rate.
Conclusion: Overall, spoken language significantly developed in both the unisensory group and the bisensory group. Thus, both the auditory-only mode and the auditory–visual mode were effective. Therefore, it is not essential to limit access to the visual modality and to rely solely on the auditory modality when instructing hearing, language, and speech in children with cochlear implants who are exposed to spoken language both at home and at school when communicating with their parents and educators prior to and after implantation.

The trial has been registered at IRCT.ir, number IRCT201109267637N1.

1. Introduction

There is no debate that severe to profound hearing loss (HL) has an effect on oral communication. A child with severe to profound HL lags behind his/her normal-hearing peers in the acquisition of auditory, oral language, and speech skills because of his or her inability to hear the sounds of the language in daily living. The optimal way to teach children with hearing loss is one of the oldest debates. There is still no consensus regarding how to provide the best language instruction and therapy for children with hearing loss [1]. The advent of cochlear implantation as a treatment for severe to profound HL has changed this debate by introducing the sounds of speech to these children. Since the introduction of

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cochlear implants (CI), communication and education before and after implantation have been a focus of research [1–4]. As Clark [5] reported, communication mode is one of the factors associated with good speech perception in children with CI. O'Donoghue et al. [1] found that young age at intervention and oral communication mode are the most important known determinants of later speech perception in young implantees. However, Eriks-Brophy [6] emphasized that "many of the most commonly used clinical approaches in audiology and speech-language pathology have never been objectively evaluated, nor their outcomes empirically documented" (p. 21).

1.1. Different intervention approaches have been advocated for the education of children with HL

The oral communication approach includes programs which emphasize using spoken language alone [7]. Proponents of this approach believe in heightening listening skills because of the important role of hearing in receiving and accurately perceiving the complex set of auditory stimuli which comprise speech [8]. The oral communication approach is divided into two types: Auditory–Oral (AO) and Auditory–Verbal Therapy (AVT). AVT is a relatively recent refinement of the AO approach [8]; the primary difference between these approaches is the use of visual cues. AO focuses on both auditory training and speech-reading, while AVT endeavors to remove or restrict visual cues, encouraging children to rely on their auditory system for acquiring words and other aspects of language [8,9]. A hand cue is one of the common techniques used in AVT to highlight linguistic and speech structures in order to encourage the child to listen attentively instead of speech-reading [10].

The choice of auditory-only or auditory–visual modalities for improving oral language skills is related to modality preference [9]. The literature indicates that when a child with normal hearing (NH) is faced with a stimulus consisting of both auditory and visual cues, for a young child, the dominant modality preferred for perceiving the stimulus is audition [9,11–13]. Results may differ in children with HL, however. Schorr et al. [14] studied the effects of auditory–visual fusion (the so-called McGurk effect) on speech perception in children with CI. In this study, a visual preference was evident in the children with CI, presumably resulting from their higher dependence on lip-reading which they had previously used to perceive speech prior to implantation. Ling [15] suggested that using the visual system for acquisition of speech and language affects the development of memory codes and eventually verbal learning, however, this is likely to differ between children depending on their ability to utilize visual versus auditory cues and also on the development of auditory–visual fusion. Sloutsky and Napolitano [12] noted that there are differences in the nature of visual and auditory processing, due to visual processing occurring in parallel and auditory processing being more serial, since speech understanding requires the listener to process a temporal sequence of speech sounds. Proponents of AVT believe that an emphasis on the visual modality will lead to its dominance over the auditory modality, making the acquisition of auditory/oral language more difficult. Thus, the view of some authors is that the best way to train children with HL with or without CI is to stress audition alone and suppress speech-reading [3,9,15]. Schow and Nerbonne [8] noted that if development of auditory skills is focused on in the child's educational program, the child trained in either auditory–verbal or auditory–visual mode of communication will progress more rapidly with their implants, however there is limited high quality evidence to support this.

To sum up, our knowledge of the effectiveness of auditory-only and auditory–visual approaches is based on limited research in the hearing-impaired population and many earlier studies included children using hearing aids rather than CI. Moreover, since there are obstacles to perform true experimental studies in this field, the majority of the available results are from non- or quasi-experimental studies. Therefore, it seems that we are confronted with an important challenge: would canceling the visual modality and compelling an implanted child to use the auditory-only modality only lead to better development of auditory, language, and speech skills? To answer this question, we compared the impact of auditory-only and auditory–visual modes of instruction for oral speech and language skills for children with HL using CI through a randomized clinical trial (RCT). The aim of this study was to examine unisensory-based (auditory–verbal) and bisensory-based (auditory–oral) approaches in children with CI. The hand cue technique of AVT [10] was used to exclude visual stimuli during instruction for children in the AVT group. This technique involves the therapist, parent, or caregiver covering his/her mouth using a hand, a toy, a picture, or a book, placed in front of the speaker's mouth [10]. Lip-reading was not trained as a skill in either group of children. To our knowledge, there are no comparable studies in the literature; thus, the findings of the present study are significant for those considering communicative and education approaches for children with HL.

2. Materials and methods

2.1. Participants

This study involved 22 Persian children with profound HL who were implanted at the Cochlear Implant Centre of Shiraz University of Medical Sciences, Shiraz, Iran. The study was carried out at Soroosh Instruction and Rehabilitation Private Centre of Hearing-Impaired Children and their Family. The inclusion criteria of the study were age <6 years, age at CI < 6 years, duration of CI < 2 years, congenital HL, normal IQ, cochlear implant model (Nucleus 22 Processor), and having no other disabilities. The children in the study were aged between 27 and 66 months old (mean = 44.14 months old, SD = 1.00) at the time of entry to the study. They received one-sided CI between the ages of 15 and 63 months old (mean = 39.50 months old, SD = 11.22). The homogeneity of two groups was confirmed statistically with respect to the background variables (Table 1).

2.2. Design

An RCT design was used. Six indices were used to determine the developmental status of the participants before and after the intervention: Pre-test Developmental Rate (PDR) [16], Post-test Developmental Rate (PoDR), Intervention Efficiency Index (IEI) [16], Mean Length of Utterance (MLU) [17,18], Speech Intelligibility Rating (SIR) [19], and Auditory Perception Rating (APR) [20]. The MLU was used to evaluate the expressive language development of the participants pre- and post-intervention and was calculated by

Table 1
The homogeneity of two groups.

Variables	AO	AV	*P*-value
Gender (F)	5 (55.6%)[†]	4 (44.4%)[†]	$p = 1.00$[*]
Gender (M)	6 (46.2%)[†]	7 (53.8%)[†]	
Age (mth)	45.45 (9.15)	42.81 (11.06)	$p = 0.55$
Age of hearing (mth)	27.64 (5.94)	21.00 (16.48)	$p = 0.09$
Age at CI (mth)	42.10 (7.85)	37.00 (13.71)	$p = 0.29$
Duration of pre-education (mth)	15.36 (13.14)	7.45 (8.62)	$p = 0.15$
Duration of CI (mth)	2.36 (2.98)	4.64 (7.25)	$p = 0.35$

Data represent means (standard deviations); *P*-value, $p < 0.05$; AO, auditory-only; AV, auditory–visual; F, female; M, male; mth, months; CI, cochlear implantation; pre-education, before intervention.
[†] Data represent number (percent).
[*] Fisher's Exact Test.

Table 2
The data of the skills assessed and their related information.

Skills assessed	Indices	Instrument(s)	Assessment times
Hearing	PDR	Newsha Development Scale	Baseline
	PoDR	Newsha Development Scale	Post-treatment
Receptive language	PDR	Newsha Development Scale	Baseline
	PoDR	Newsha Development Scale	Post-treatment
Speech	PDR	Newsha Development Scale	Baseline
	PoDR	Newsha Development Scale	Post-treatment
Expressive language	PDR	Newsha Development Scale	Baseline
	PoDR	Newsha Development Scale	Post-treatment
	MLU	Picture description Conversation methods	Baseline
		Mothers' reports	Post-treatment
Auditory perception	APR	Tavana Test	Baseline
			Post-treatment
Speech intelligibility	SIR	Speech Intelligibility Measurement Test	Baseline
			Post-treatment

PDR, Pre-test Developmental Rate; PoDR, Post-test Developmental Rate; MLUm, Mean Length of Utterance; APR, Auditory Perception Rating; SIR, Speech Intelligibility Rating.

dividing the total number of morphemes by the total number of the utterances, based on maternal report. The SIR was utilized in order to assess the children's speech intelligibility. SIR was calculated by dividing the number of words clearly produced by the child by the total number of words, as assessed by a speech therapist who was blinded to group allocation. Several measures were derived from the assessments of auditory perception, speech, and language. The PDR (based on measures of baseline auditory, speech and language skills) was employed to determine the rate of skill development in the participants pre-intervention and was computed by dividing the pre-intervention skill age by the child's chronological age. The PoDR was used to determine the rate of skill development in the children post-intervention and was computed by dividing the post-intervention skill age by the child's chronological age. To calculate the IEI, the intervention efficiency index, the pre-intervention skill age was subtracted from the post-intervention skill age and then, the result of the subtraction was divided by the length of time of the intervention (Table 2).

2.3. Instruments

We evaluated the children using three tests: the Newsha Development Scale as a norm-referenced test for the 0–6 year-old Persian children included four subtests of hearing, receptive language, expressive language, and speech [21,22]; the Tavana Test as a criterion-referenced test for Auditory Skills Evaluation of 3–4 year-old hearing-impaired Persian children included four subtests of detection, discrimination, identification, and sentence comprehension that is only published in Persian. The Tavana Test assesses a hierarchy of auditory skills progressing from detection and discrimination of speech and non-speech sounds to speech understanding [20]. The Speech Intelligibility Measurement Test for 3–5 year-old Persian children used to determine SIR consisted of 34 single pictured words and it is only published in Persian [19]. This test involves the children producing a word that matches a picture; the pictures depict common nouns such as/pa/(foot). In addition, picture description and conversation methods [17,18] were employed for measuring MLU in the implanted children. All the test instruments have been validated in the Persian population. Jafari et al. [21,22] reported correlation coefficients of more than 0.95 for both test-retest and inter-rater reliability, and correlation coefficients of more than 0.90 for content and construct validity for the Newsha Scale. Jarollahi et al. [20] reported a correlation coefficient of 0.94 for content validity of the Tavana Test. Heydari et al. [19] obtained an intraclass correlation coefficient of 0.85 for the Speech Intelligibility Measurement Test indicating good item reliability.

2.4. Procedure

The work was approved by the Ethics Committee of University of Social Welfare and Rehabilitation Sciences and subjects' parents gave informed consent to participate in the study. It was planned to recruit as many subjects as possible in the study within a period of 7 months. In total, 30 children were assessed for eligibility and eight of them were excluded from the study prior to randomization and baseline data collection due to not meeting the inclusion criteria ($n = 4$), unwillingness to participate in the study ($n = 2$), and immigration ($n = 2$). Finally, 22 children were selected. An intention-to-treat (ITT) analysis was possible because complete outcome data were available for all randomized subjects. The lead and the seventh authors of this paper (who are speech therapists experienced in working with children with HL) evaluated each child's auditory and verbal skills at baseline. Based on this evaluation, PDR was measured for each of hearing skills, receptive language skills, expressive language skills, and speech skills; MLU, APR, and SIR was measured as well. After assessing child at baseline, the lead author randomly assigned individual participants to either the unisensory or the bisensory treatment group, using a coin toss for the first participant and alternating group assignment thereafter. Finally, each group included 11 subjects. An experienced instructor who was both the mother of a hearing-impaired boy and the instructor of the children with hearing impairment in the school instructed both study groups. The same educational program composed of auditory training, language stimulation, and speech correction was executed for both study groups; however, the sole difference was the manner of instruction. Group 1 could not look at the instructor's and their mothers' lips when they were speaking (auditory-only mode). Both the instructor and the mothers were trained to use the hand cue to inhibit lip-reading (as indicated in the AVT approach). Group 2 could look at the instructor's and their mothers' lips when they were speaking (auditory–visual mode). Each group was trained for 3 and half hours every other day. During the rest of their day children were at home with their families. Families were instructed to communicate with their children by auditory-only mode in Group 1 and auditory–visual mode in Group 2. The total intervention lasted for 13 months. Another speech therapist who was blind to treatment evaluated each child's hearing, language, and speech development using the Newsha Scale and each child's auditory skills using the Tavana Test. The instructor and the children's mothers assisted the speech therapist during the evaluation sessions. The mothers were trained to accurately note their children's spontaneous speech samples in routine conversational situations every day and present a copy of them to the speech therapist monthly. These speech samples in addition to those ones which were elicited by the speech therapist using the method of picture description were transcribed and used to calculate the MLU for each child. All the evaluation sessions were filmed and results were verified by an independent speech therapist. Based on the post-treatment data, the IEI was calculated for each child's measures of hearing, receptive and expressive language, and speech skills. Finally, the two groups' development was compared statistically based on the subjects' IEI, MLU, SIR, and APR results.

2.5. Statistical analysis

Statistical analyses were conducted using the Statistical Package for Social Sciences (SPSS 13.0 for Windows). The homogeneity of the groups was examined by means of independent *t*-tests (age, age at CI, duration of CI), Mann–Whitney *U* (hearing age, duration of pre-treatment education), and Chi square (gender) tests. A multivariate analysis of variance (MANOVA) was used in order to compare the PDR and the IEI scores between the groups. APR, MLU, and SIR scores of the groups were examined by means of independent *t*-tests. Paired pre- versus post-treatment *t*-tests were used to compare the PDR, PoDR, APR, MLU, and SIR scores within each group. A *p*-value of less than 0.05 was accepted as statistically significant.

3. Results

3.1. The efficiency of the modes between the groups

3.1.1. Pre-test developmental rate and intervention efficiency index

The means and standard deviations for the PDR scores for hearing, receptive language, expressive language, and speech development skills in the auditory and the auditory–visual groups are summarized in Table 3. The MANOVA showed no statistically significant difference between the two groups' PDR scores ($p = 0.377$), indicating that the two groups had the same developmental status at baseline prior to the intervention.

The means and standard deviations for the IEI for hearing, receptive language, expressive language, and speech development skills of the unisensory and the bisensory groups are shown in Table 3. Both groups showed improvement. The MANOVA identified no statistically significant difference between the IEI scores of the groups ($p = 0.598$). Thus, the auditory-only and auditory–visual modes of instruction produced similar improvements in the oral skills of the implanted children.

Table 3
MANOVA results for PDR and IEI scores of the groups.

Skills	PDR score*		IEI score†	
	AO	AV	AO	AV
Hearing	0.33 (0.26)	0.37 (0.22)	2.03 (1.07)	2.02 (0.78)
Receptive language	0.34 (0.20)	0.41 (0.21)	2.40 (1.14)	2.02 (0.81)
Expressive language	0.42 (0.24)	0.38 (0.22)	1.83 (1.06)	1.82 (0.71)
Speech	0.37 (0.17)	0.39 (0.24)	2.85 (0.97)	2.64 (1.02)

Data represent means (standard deviations); AO, auditory-only; AV, auditory-visual; PDR, pre-test developmental rate; IEI, intervention efficiency index.
* ($F_{(4,17)} = 1.127$; $p = 0.377$; Wilks' Lambda = 0.790, partial $\eta^2 = 0.210$).
† ($F_{(4,17)} = 0.708$; $p = 0.598$; Wilks' Lambda = 0.857, partial $\eta^2 = 0.143$).

3.1.2. Auditory perception rating, mean length of utterance, and speech intelligibility rating

Table 4 exhibits means and standard deviations for the APR, MLU, and SIR scores of the auditory and the auditory–visual groups before and after the intervention. No statistically significant differences were found between the auditory and the auditory–visual groups before the intervention in terms of APR ($p = 0.319$), MLU ($p = 0.259$), and SIR ($p > 0.05$). Therefore, the groups had the same auditory, speech, and language development before the intervention, as was seen for the PDR and IEI scores.

Again, no statistically significant difference was observed between the group means after the intervention in terms of APR ($p = 0.376$), MLU ($p = 0.732$), and SIR ($p = 0.237$). Thus, the study found no difference in the development of auditory, speech, and language skills of the children using CI between the auditory and the auditory–visual mode.

3.2. The efficiency of the modes within the groups

3.2.1. Pre-test developmental rate and post-test developmental rate

Table 5 illustrates means and standard deviations for the PDR and the PoDR of hearing, receptive language, expressive language, and speech skills in the 22 implanted children before and after the intervention. Paired *t*-tests showed that the children's hearing skills, receptive and expressive language, and speech skills had significantly developed after the intervention ($p < 0.001$) in both the unisensory and the bisensory groups. Thus, both the auditory-only mode and the auditory–visual mode were effective.

3.2.2. Auditory perception, mean length of utterance, and speech intelligibility

The children's SIR, APR, and MLU scores also improved after the intervention ($p < 0.001$) both the auditory-only and auditory–visual groups, as summarized in Table 6. The children's speech intelligibility results after the intervention indicated that their speech was more intelligible for unfamiliar talkers. After the intervention period children in both groups had auditory perception scores that indicated that they were able to perceive both closed-set and open-set comperehension tasks.

The children's MLU after the intervention period increased on average indicating that, compared to expected results for typically developing children [18], the children with hearing loss in this study has morphological development consistent with younger typically developing children.

4. Discussion

This study showed that the children with hearing loss who had received CI recently and had been instructed using the

Table 4
Independent *t*-test results for APR, MLU, and SIR scores of the groups before and after the intervention.

Time point	APR score			MLU score			SIR score		
	AO	AV	*P*-value	AO	AV	*P*-value	AO	AV	*P*-value
Pre-intervention	0.39 (0.18)	0.32 (0.14)	0.319	1.36 (0.41)	1.67 (0.77)	0.259	0.0 (0.0)	0.0 (0.0)	$p > 0.05$
Post-intervention	0.96 (0.05)	0.93 (0.10)	0.376	3.54 (1.23)	3.72 (1.28)	0.732	0.18 (0.10)	0.27 (0.20)	0.237

Data represent means (standard deviations); *P*-value, $p < 0.05$; AO, auditory-only; AV, auditory–visual; APR, auditory perception rating; MLU, mean length of utterance; SIR, speech intelligibility rating.

Table 5
Paired *t*-test results for PDR and PoDR scores of the children.

Skills	PDR	PoDR	*P*-value
Hearing	0.35 (0.24)	0.66 (0.18)	$p < 0.001$
Receptive language	0.37 (0.20)	0.71 (0.18)	$p < 0.001$
Expressive language	0.40 (0.23)	0.66 (0.17)	$p < 0.001$
Speech	0.38 (0.20)	0.72 (0.17)	$p < 0.001$

Data represent means (standard deviations); PDR, pre-test developmental rate PoDR, post-test developmental rate.

auditory-only or auditory–visual modes acquired auditory, receptive language, expressive language, and speech skills at the same rate. Their MLU and intelligibility of speech was also comparably developed. Participating children were randomly assigned to two groups and no significant difference was found between the groups regarding the background variables before the intervention. In conclusion, it seems that canceling and adding the visual modality when children with hearing loss are receiving auditory instruction and therapy does not affect the outcomes of auditory training and oral language instruction in Persian-speaking children receiving a CI at 1–5 years of age.

Overall, the studies conducted on children with normal hearing have revealed two main principles [9,11–13]: (1) young children with normal hearing prefer the auditory modality when confronted with a stimulus consisting of both auditory and visual cues and (2) this auditory preference is likely to occur automatically in infancy and early childhood because of the essential role of audition in word learning and oral language development. According to Ling [15], ‘‘we can receive all of these [acoustic] features [of speech] through audition, while partial information about duration and place can be received through vision’’. In support of this view that the auditory modality is dominant in oral language acquisition, blindness typically does not result in delay in the development of oral language. As Hoff [23] mentioned ‘‘blind children who have no other handicapping condition babble, produce first words, produce the combinations, and acquire syntax and morphology on essentially in the same timetable as do sighted children’’. Thus it appears that the visual modality has a subordinate role in the acquisition of oral language because limited information can be received by lip-reading. Auditory–visual integration is not mature in young children and the auditory modality dominates when auditory and visual stimuli are presented together [24]. Thus, although lip-reading may support the acquisition of oral language, it appears that audition has the main role in the acquisition of language skills and vision has a lesser role in typically developing children. Although it is possible for children with significant hearing loss to acquire receptive and expressive language in the visual modality, using sign language [25], the principles of audiovisual processing in typically developing children are likely to apply to children with hearing loss who are using hearing instruments and listening to spoken language. All the children in the current study had used hearing aids between 0.6 and 4.5 years prior to implantation. With hearing aids they could receive environmental sounds and some parts of the speech signal through their residual audition. Also, as their parents all had normal hearing, the use of listening had been emphasized at home as well as in the educational setting. Accordingly, their auditory and receptive language skills had developed at the time of implantation, although all children had some language delay. The lack of difference in outcomes for the two interventions suggests that eliminating the visual modality in AVT did not change the child's use of the auditory modality compared to the other group which had access to lipreading cues, and compared to the pre-intervention phase where all participants had access to lipreading cues. Cochlear implants enable the child to receive the speech signals across a wide range of frequencies, comparable to the detection abilities of a child with NH. Thus the lack of difference between the unisensory and bisensory approaches here may be due to the CI providing a very good speech signal resulting in a preference for the auditory modality to process speech whether or not the child can see the mouth and facial expression of the speaker. The AVT approach with use of the hand to remove visual cues and focus the child on listening may, however, have advantages for children with CI who have high reliance on lip-reading or sign language. This should be investigated in future studies to find out which approach is optimal for children with greater reliance on the visual modality for communication prior to implantation.

Regardless of whether the children were in the auditory-only or auditory–visual group, their auditory–oral skills significantly improved after the intervention. In other words, for the children investigated here, both modes were effective in developing the auditory perception and oral speech and language skills of the implanted children. Although there is a lack of similar studies in the literature to compare these findings to, the results are consistent with the views of others examining the development of speech and spoken language skills of children with hearing loss [8,14]. Schorr et al. [14] found that most of the implanted children in their study showed a visual dominance in the McGurk effect test, when auditory and visual speech information is conflicting, presumably because of depending on lip-reading for speech perception before implantation. However, Schorr et al.'s participants used oral language as the primary mode of communication and could perceive spoken language, thus they could effectively use auditory cues to perceive the speech stimulus in communication regardless of the visual preference they showed on the McGurk effect test. Consistent with the findings of the current study, Schow and Nerbonne [8] asserted that if the educational program for children with CI emphasizes the development of auditory skills, children trained in either auditory–verbal or auditory–visual modes of communication will progress with their implants.

Table 6
Paired *t*-test results for SIR, APR, and MLU scores of the children pre- and post-intervention.

SIR score			APR score			MLU score		
Pre	Post	*P*-value	Pre	Post	*P*-value	Pre	Post	*P*-value
0.0 (0.0)	0.23 (0.16)	$p < 0.001$	0.36 (0.16)	0.95 (0.08)	$p < 0.001$	1.52 (0.62)	3.63 (1.23)	$p < 0.001$

Data represent means (standard deviations); pre, before the intervention; post, after the intervention.
APR, auditory perception rate; MLU, mean length of utterance; SIR, speech intelligibility rate.

5. Conclusion

The results of the current study indicate that the use of the hand cue might either be ineffective in preventing an implanted child from receiving the visual stimuli from the speaker's mouth or the access to visual cues for the bimodal intervention group did not affect their reliance on audition for communication development. Our findings indicate that it is not essential to cancel or limit the visual modality in order to rely on the auditory modality when working on the development of hearing, language, and speech in children with CIs who are experiencing speech in different auditory/oral environments, including home and school. We recommend that habilitation programs for children with CIs focus on reinforcing auditory and listening skills, without removing access to speech reading cues, when children are engaged in learning activities to enhance their language and speech skills.

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References

[1] G.M. O'Donoghue, Nikolopoulos T.P., S.M. Archbold, Determinants of speech perception in children after cochlear implantation, Lancet 356 (2000) 466–468.
[2] M.S. Jimenez, M.J. Pino, J. Herruzo, A comparative study of speech development between deaf children with cochlear implants who have been educated with spoken or spoken + sign language, Int. J. Pediatr. Otorhinolaryngol. 73 (2009) 109–114.
[3] D. Dornan, L. Hickson, B. Murdoch, T. Houston, G. Constantinescu, Is auditory–verbal therapy effective for children with hearing loss? Volta Rev. 110 (2010) 361–387.
[4] S. Hassanzadeh, Outcomes of cochlear implantation in deaf children of deaf parents: comparative study, J. Laryngol. Otol. 126 (2012) 989–994.
[5] G. Clark, Cochlear implants in children: safety as well as speech and language, Int. Congr. Ser. 125 (2003), pp. 47–25.
[6] A. Eriks-Brophy, Outcomes of auditory–verbal therapy: a review of the evidence and a call for action, Volta Rev. 104 (1) (2004) 21–35.
[7] C.M. Connor, S. Hieber, H.A. Arts, T.A. Zwolan, Speech, vocabulary, and the education of children using cochlear implants: oral or total communication? J. Speech Lang. Hear. Res. 43 (2000) 1185–1204.
[8] R.L. Schow, M.A. Nerbonne, Introduction to Audiologic Rehabilitation. Pearson Education, 5th ed., Allyn and Bacon, Boston, 2007, pp. 270–280.
[9] B. Zupan, J.E. Sussman, Auditory preferences of young children with and without hearing loss for meaningful auditory–visual compound stimuli, J. Commun. Disord. 42 (2009) 381–396.
[10] W. Estabrooks, 50 Frequently Asked Questions About Auditory–Verbal Therapy. Alex Graham Bell Assn for Deaf, 1st ed., Volta Place, N.W., Washington, 2000, pp. 30–50.
[11] A.C. Napolitano, V.M. Sloutsky, Is a picture worth a thousand words? The flexible nature of modality dominance in young children, Child Dev. 75 (2004) 1850–1870.
[12] V.M. Sloutsky, A.C. Napolitano, Is a picture worth a thousand words? Preference for auditory modality in young children, Child Dev. 74 (2003) 822–833.
[13] C.W. Robinson, V.M. Sloutsky, Auditory dominance and its change in the course of development, Child Dev. 75 (2004) 1387–1401.
[14] E.A. Schorr, N.A. Fox, V. Wassenhove, E.I. Knudsen, Auditory–visual fusion in speech perception in children with cochlear implants, PNAS 102 (2005) 18748–18750.
[15] D. Ling, Speech and the Hearing-Impaired Child: Theory and Practice. Alex Graham Bell Assn for Deaf, 2nd ed., Volta Place, N.W., Washington, 2002, pp. 45–62.
[16] J. Samadi, M. Sedaei, N. Rouhbakhsh, S. Asad Malayeri, S. Faghih zadeh, Preparation and evaluation of SKI-HI: a parent-infant auditory training program for under 3-year-old hearing impaired children, Audiology 15 (1) (2006) 20–26[Persian].
[17] M.M. Oryadi Zanjani, R. Ghorbani, F. Keikha, Standardization of total numbers of word, mean length of utterance and mean length of 5 long sentences in normal Persian language children between 2 to 5 years old in Semnan city, J. Semnan Univ. Med. Sci. 7 (3) (2006) 177–182[Persian].
[18] M.M. Oryadi Zanjani, B. Mahmoudi Bakhtiyari, M. Vahab, S. Jafari, Efficiency of picture description and storytelling methods in language sampling according to the mean length of utterance index, Audiology 21 (3) (2012) 18–23 [Persian].
[19] S. Heydari, F. Torabi Nezhad, Z. Agha Rasouli, F. Hoseyni, Development of speech intelligibility measurement test for 3 to 5 years old normal children, Audiology 20 (1) (2011) 47–53[Persian].
[20] F. Jarollahi, Y. Modarresi, M.R. Keyhani, Content validity of Tavana: a test for evaluation of auditory skills of 3–4 year-old hearing-impaired Persian children, Audiology 19 (1) (2010) 11–22[Persian].
[21] Z. Jafari, H. Ashayeri, S. Malayeri, F. Alaedini, Translation, reliability and validity of the Newsha Hearing, Language and Speech Development Scale among children in Iran, Payesh 8 (3) (2009) 271–278[Persian].
[22] Z. Jafari, S. Asad-Malayeri, The psychometric properties of Newsha Developmental Scale: an integrated test for Persians speaking children, Iran J. Pediatr. 22 (1) (2012) 28–34.
[23] E. Hoff, Language Development. Cengage Learning, 4th ed., Cheriton House, Hampshire, 2009, pp. 378–385.
[24] R.N. Desjardins, J.F. Werker, Is the integration of heard and seen speech mandatory for infants? Dev. Psychobiol. 45 (2004) 187–203.
[25] S. Hassanzadeh, Outcomes of cochlear implantation in deaf children of deaf parents: comparative study, J. Laryngol. Otol. 126 (10) (2012) 989–994.